UNITED STATES DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN

WASHINGTON, D. C. 711 MARCH 22, 1916

Contribution from the Forest Service, Henry S. Graves, Forester.

THE CARE AND IMPROVEMENT OF THE WOOD LOT.

By C. R. TILLOTSON, *Forest Examiner.*

CONTENTS.

INTRODUCTION.

Wood grown in the farm wood lot is a farm crop. That it is, however, is too often overlooked, because, unlike other farm crops, timber requires a small amount of labor and a long period of years to bring it to a marketable condition. If properly cared for, a wood lot will furnish material for market at intervals, and will afford a supply of timber, fuel, etc., for home use at all times. If neglected or abused, it is bound to deteriorate, and may eventually disappear altogether. The aim of this bulletin is to point out methods of caring for the wood lot and improving it so as to make it produce the largest and best crop of which it is capable.

ESSENTIALS OF A GOOD WOOD LOT.

The wood-lot crop, like any other, should be judged by its quantity and quality. To secure a full stand of trees of high quality, therefore, should be the farmer's aim. Fortunately, the quality of timber is very largely determined by how dense the stand is; that is, how close together the trees are. To be of high quality, timber

must be, to a considerable proportion of its height, free of limbs, which are the cause of knots; it must be tall; and it must not decrease rapidly in diameter from the butt to the top of the last log. In a dense stand of timber there is considerable competition for sunlight among the individual trees, with the result that height growth is increased. Trees in crowded stands are taller than those in uncrowded stands of the same age. When the trees are crowded so that sunlight does not reach the lower branches, these soon die and become brittle; they then fall off or are broken off by the wind, snow, or other agencies. By this process trunks are formed which are free of limbs, and hence of high quality. Further, when trees are crowded their diameters do not decrease rapidly from the butts to the tops. In uncrowded stands just the opposite is true: height growth is less; the lower branches continue to live, increase in size, and form large knots; and there is a much greater taper in the trunks of the trees. It is evident, therefore, that trees in the wood lot should be so crowded that the crown or top of each individual tree may be in contact with those of its nearest neighbors. A crowded stand of trees produces not only a larger number but also a greater proportion of high quality sawlogs than an uncrowded stand of an equal area. This is of vital importance, because the price of logs of first quality is usually from one and one-half to two times as much as that paid for logs of poor quality.

STOCKING.

The approximate number of trees which should be present per acre is given in Table 1. The figures are applicable to oak, aspen, hickory, elm, and ash, but are from 15 to 20 per cent too low for maple, basswood, yellow birch, beech, and white or red pine.

TABLE 1.—*Number of trees which should be present per acre.*[a]

Diameter.[b]	When diameter of trees ranges from—				When trees are all of a uniform diameter.
	2 to 10 inches.	2 to 14 inches.	6 to 18 inches.	10 to 24 inches.	
Inches.	*Trees.*[c]	*Trees.*[c]	*Trees.*[c]	*Trees.*[c]	*Trees.*[c]
2	400	300	.....	.....	2,000
4	180	130	.....	.....	900
6	105	75	75	.....	510
8	65	45	45	.....	320
10	50	30	30	30	235
12	.....	25	25	20	170
14	.....	20	20	16	130
16	.....	.....	15	12	100
18	.....	.....	12	11	85
20	.....	.....	.....	9	75
22	.....	.....	.....	8	65
24	.....	.....	.....	7	55
Total per acre	800	625	222	113	.....

[a] Data furnished by Prof. E. L. Sponsler, University of Michigan.
[b] Diameters taken at 4½ feet from the ground.
[c] Of the respective diameters indicated in the first column.

SPECIES.

From the marketing standpoint, some species are preferable to others. Black walnut, white oak, and yellow poplar, for instance, are now of more value than basswood, red gum, or beech. It is probably best, however, to grow in the wood lot those species which will produce the largest amount of material within a specified time rather than to attempt to grow the species most valuable now. This means that trees of the most rapid growth which are well adapted to the region and situation and not subject to serious insect or fungous [1] attacks should be favored. By regions the most prevalent species in the wood lot are:

1. Northern Michigan, Wisconsin, and Minnesota: White, jack, and red pines, aspen, yellow birch, basswood, scarlet, black, and red oaks, white ash, elm, hemlock, hard maple, and beech.

2. Southern Michigan, Wisconsin, Minnesota, and northern Indiana: Red, white, and black oaks, white ash, basswood, elm, hickory, maple, and beech.

3. Southern Indiana, Illinois, southeast Missouri, western Kentucky, and western Tennessee: Yellow poplar, black walnut, red gum, white oaks of several species, black oak, red oak, cottonwood, red elm, hickory, white ash, beech, and maple.

4. Eastern Kentucky and Tennessee: Yellow poplar, white ash, red oak, black walnut, black cherry, chestnut, chestnut oak, white oak, red oak, hickory, white pine, and shortleaf pine.

5. Ozark region of Missouri: Shortleaf pine, black oak, walnut, red cedar, several species of white oak, and black jack oak, red elm, and hickory.

6. Ohio: Yellow poplar, white ash, basswood, red and black oaks, walnut, white oak, red elm, hard maple, beech, and hickory.

7. New England: White pine, red spruce, hemlock, arborvitæ, white cedar, balsam fir, chestnut, red and black oaks, hard maple, red maple, beech, yellow birch, paper birch, gray birch, black birch, aspen, tulip poplar, white ash, elm, basswood, and hickory.

8. North Atlantic States: White pine, hemlock, arborvitæ, white cedar, balsam fir, pitch pine, chestnut, red, white, and black oaks, hard maple, red maple, beech, yellow birch, black birch, tulip poplar, white ash, cucumber, black gum, elm, basswood, and hickory.

9. South Atlantic and Southern States: Loblolly, shortleaf, longleaf, and scrub pines, cypress, white, black, and red oaks, black walnut, tulip poplar, white ash, red, black, and tupelo gums, beech, and hickory.

The comparative rates of diameter growth of the most important of these species for which data are available are about as shown in

[1] Chestnut is of rapid growth but is subject to such serious fungous attack (chestnut blight) that it should be supplanted by other species.

Table 2. For the rate of growth in any specific locality, Table 3 should be examined.

TABLE 2.—*Comparative rates of diameter growth of trees.*[a]

Average number of years to grow 1 inch in diameter.	Species.
2 years	Cottonwood.
3 to 4 years	Yellow poplar, red gum, loblolly pine.
3 to 5 years	Shortleaf pine, black locust, chestnut, bald cypress, scrub pine.
4 to 7 years	Black walnut, white pine, red pine, white ash, red oak, black oak, aspen.
6 to 9 years	Hickory, white oak, chestnut oak, post oak, burr oak, basswood, paper birch.
8 to 10 years	Red spruce (second growth).
9 to 18 years	Hard maple, yellow birch, beech, white elm, hemlock, balsam fir.
18 to 25 years	Arborvitæ.

[a] Table is based on growth of trees in natural unmanaged stands. Under proper management, much more rapid growth can be secured, particularly of those species in the last four lines.

The slower growing species, particularly those in the last four lines, will not reach merchantable size as soon as the others, and from an investment standpoint should not be favored in the young growth, provided some of the more rapid-growing kinds will succeed on the wood-lot site. The value of these slow-growing species for farm purposes, however, will often make it equally desirable to encourage the growth of at least a few of them if the owner wishes material particularly fitted for his own farm uses.

IMPROVEMENT, CARE, AND PERPETUATION.

By far the greater number of farm wood lots are in need of improvement. Poorer species are in the majority and are crowding out the better ones, many of the trees are overmature, some show evidence of insect or fungous attack, some are dead, young trees are entirely wanting in the open places, and grazing is allowed to the extent of damaging the older trees and preventing reproduction. Improvement of these conditions can be secured through the judicious use of the axe, by assisting natural reproduction, by the exclusion of stock at least from portions of the wood lot, and, where necessary, through planting or sowing. Nearly every individual wood lot presents its own specific problem for solution in these respects, and it is impossible to do more in a publication than to indicate some of the general features which should be considered. More detailed advice can be given only when exact conditions for individual cases are known.

There are two general types of wood lots, each of which requires a different method of handling: (1) Wood lots which are characterized by the presence of old trees which dominate the stand, and (2) wood lots which are made up of a nearly even-aged stand of second growth.

1. Wood lots characterized by the presence of old trees which dominate the stand.

TABLE 3.—*Average growth of various species in different regions.*

Species.	Region.	Age. 20 years. Diameter at height of 4½ feet.	20 years. Height.	30 years. Diameter at height of 4½ feet.	30 years. Height.	40 years. Diameter at height of 4½ feet.	40 years. Height.	50 years. Diameter at height of 4½ feet.	50 years. Height.	60 years. Diameter at height of 4½ feet.	60 years. Height.	80 years. Diameter at height of 4½ feet.	80 years. Height.	100 years. Diameter at height of 4½ feet.	100 years. Height.
		Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Aspen	Maine	2.4- 5.3	17-40	3.6- 8	28-55	4.7-10.4	39-66	5.8-12.7	50-75	7.0-14.8	57-81	9.3-19.2	64-87	11.7-23-3	66-89
Arborvitæ	Minnesota	.7	4.7-8	1.2	5.7-11	1.6	13	2.1	15	2.8	18	4.2	25	6.2	32
Ash, white	New York (good soil)	4.5- 8.2	34-52	7.1-12.2	47-67	9.4-15.3	57-75	11.2-17.7	65-79	13.1-19.6	71-81	16.5-22.8	81-83	.....	.....
Do	Ind. (fair to poor upland)	1.6- 2.5	17-34	2.5- 4.1	26-45	3.5- 5.9	34-54	4.6- 8.2	41-62	6.0-10.9	47-68	10.3-18.4	57-78	.....	.....
Ash, green	S. Carolina (bottomland)	4.9- 9.4	41-57	7.1-12.8	52-69	9.1-15.7	62-79	11.0-18.5	70-87	12.9-21.1	78-95	16.4-25.9	90-107	19.7-30.5	100-117
Do	Arkansas (bottom land)	4.9- 7.8	31-(?)	7.4-11.4	45-(?)	9.7-14.6	57-(?)	11.7-17.4	67-(?)	13.5-19.9	76-(?)	17.0-24.2	92-(?)	20.1-28.1	105-(?)
Basswood	Michigan and Wisconsin	2.2- 3.3	23-32	3.6- 5.1	34-44	5.0- 6.9	43-54	6.5- 8.8	52-63	7.9-10.7	59-70	10.9-14.3	71-80	13.8-17.6	78-85
Beech	Michigan	.7- 1.3	13-19	1.5- 2.3	21-28	2.3- 3.3	28-35	3.0- 4.4	33-42	3.8- 5.4	39-48	5.4- 7.5	48-59	7.1- 9.6	57-68
Do	New York	1.0- (?)	10-16	1.5- (?)	14-23	2.0- (?)	18-30	2.5- (?)	22-36	3.1- (?)	26.41	4.6- (?)	33-52	6.4- (?)	41-61
Birch, yellow	Michigan and Wisconsin	1.1- 2.1	20-30	1.7- 3.3	26-39	2.3- 4.6	31-48	3.0- 5.8	37-54	3.8- 7.1	43-60	5.6- 9.8	53-68	7.7-12.5	62-73
Do	New York	1.8- (?)	14-22	2.6- (?)	19-31	3.5- (?)	24-40	4.5- (?)	29-47	5.4- (?)	33-53	7.4- (?)	39-64	9.4- (?)	46-74
Cedar, red	Alabama (open stand)	3.9	19.6	6.9	27.1	9.3	.....	11.2	.....	12.8	.....	15.6	.....	.....	.....
Do	Alabama (forest grown)	1.3	13.0	2.7	23.2	4.4	33.4	6.5	.....	8.9	.....	13.9	.....	.....	.....
Do	New York (forest grown)	1.9	.....	2.8	.....	3.6	.....	4.2	.....	4.8	.....	.....	.....	.....	.....
Chestnut	Maryland (sprouts)	6.8	42	9.3	57	11.4	69	13.4	77	15.1	83	18.0	90	19.8	93
Do	Maryland (from seed)	3.4	17	6.0	33	8.7	52	11.2	64	13.4	73	17.2	84	20.1	91
Do	East Tenn. (from seed)	.....	36-55	.....	46-71	.....	52-84	.....	57-92	.....	61-98	.....	66-107	.....	.....
Do	East Tenn. (cove type)	3.1	.....	5.6	.....	8.2	.....	11.1	.....	13.7	.....	18.4	.....	21.7	.....
Do	East Tenn. (slope type)	2.5	.....	4.8	.....	7.2	.....	9.4	.....	11.4	.....	14.5	.....	16.9	.....
Do	Connecticut	3.4	.....	6.4	.....	9.5	.....	12.6	.....	15.6	.....	21.7	.....	27.8	.....
Do	West Va. (slope type)	2.4	.....	4.3	.....	6.4	.....	8.4	.....	10.4	.....	14.4	.....	18.2	.....
Do	New York	4.9	.....	7.2	.....	9.4	.....	11.4	.....	12.9	.....	.....	.....	.....	.....
Cottonwood	Mississippi Valley	12.3	97	17.4	115	22.0	127	26.5	136	.....	.....	.....	.....	.....	.....
Do	South Carolina	12.6	.....	17.4	.....	21.4	.....	25.1	.....	28.2	.....	33.5	.....	37.6	.....
Bald cypress	Louisiana	5.2- 8.1	31-45	8.1-12.2	43-61	10.8-15.9	54-75	13.3-19.2	65-86	15.8-22.2	74-97	21.3- (?)	92-(?)	.....	.....
Do	Maryland	3.5-10.0	22-44	6.2-14.2	33-58	8.7-17.6	46-71	11.1-20.5	60-82	13.3-23.2	72-91	17.3-28.6	88-106	21.3-33.3	101-119
Elm, white	Michigan and Wisconsin	.9- 2.8	21	1.7- 4.3	28	2.5- 5.7	34	3.3- 7.0	40	4.1- 8.2	45	5.7-10.4	53	7.3-12.6	61
Do	New York	3.6- 5.9	24-39	5.2- 8.4	31-50	6.6-10.6	37-57	7.9-12.5	41-62	9.2-14.2	45-66	.....	.....	.....	.....
Fir, balsam	do	1.0- 1.3	14-22	1.8- 2.6	19-34	2.8- 4.0	27-45	3.8- 5.4	32-54	4.9- 6.5	36-61	6.5- 8.2	43-69	7.6- 9.5	48-73
Do	Maine	1.2	14-22	2.7	25-42	4.1	36-55	5.5	45-63	6.7	52-69	8.9	64-78	10.7	71-83
Gum, red	South Carolina [a]	7.9	.....	11.2	.....	14.2	.....	16.8	.....	19.2	.....	23.4	.....	26.9	.....
Do	Missouri	3.8	.....	6.3	.....	9.2	.....	12.2	.....	15.1	.....	20.9	.....	25.8	.....
Hemlock	Michigan	0.7- 2.0	8-18	1.3- 3.9	12-21	2.1- 5.7	16-42	2.9- 7.6	20-53	3.8- 9.4	25-62	5.7-12.8	35-76	7.8-16.1	44-85
Do	Southern Appalachians	.2- 4.0	(?)-29	.9- 6.7	9-41	1.3- 9.0	11-53	1.9-11.2	14-63	2.4-13.1	17-71	3.6-16.9	24-86	4.9-20.6	31-98
Do	New York	.4- 1.5	7-17	.9- 2.9	10-28	1.4- 4.4	13-39	1.9- 5.9	16-49	2.5- 7.4	20-58	4.0-10.5	28-73	5.5-13.8	36-84

[a] Diameter on stump.

TABLE 3.—*Average growth of various species in different regions*—Continued.

Species.	Region.	Age.													
		20 years.		30 years.		40 years.		50 years.		60 years.		80 years.		100 years.	
		Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.
		Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Hickory	New York	3.6	.....	5.4	.....	7.1	.....	8.6	.....	10.0	.....	.....	.....	.....	.....
Mockernut	Ohio Valley	2.6	.....	4.3	.....	6.0	.....	7.7	.....	9.3	.....	12.5	.....	15.7	.....
Pignut	do	1.8	.....	3.1	.....	4.4	.....	5.7	.....	7.2	.....	10.0	.....	12.9	.....
Shagbark	do	1.7	.....	2.9	.....	4.1	.....	5.3	.....	6.5	.....	9.0	.....	11.6	.....
Pignut	Northern Kentucky and southern Indiana (fair to good soil second growth).	2.0	19	3.2	32	4.4	42	5.5	51	6.8	58	10.0	69	.....	.....
Shagbark		2.8	18	4.0	32	5.4	43	6.8	51	8.0	58	10.5	70	.....	.....
Bitternut		4.0	24	6.0	40	7.6	52	9.2	62	11.4	69	.....	.....	.....	.....
Pignut	Northern Kentucky and southern Indiana (coppice; red clay soil).	3.8	31	5.5	43	7.0	52	8.5	59	.....	.....	.....	.....	.....	.....
Shagbark		4.4	26	6.3	38	7.4	46	8.6	54	.....	.....	.....	.....	.....	.....
Locust, black	Kentucky (close stand)	5.2	.....	7.1	.....	8.7	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	Kentucky (broken stand)	6.0	.....	9.0	.....	10.7	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	Kentucky (open stand)	9.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Maple, sugar or hard.	Michigan and Wisconsin.	0.5–1.2	10–18	1.2– 2.3	18–29	1.9– 3.6	25–39	2.7– 4.9	32–48	3.5– 6.3	38–55	5.2– 9.1	49–67	7.0–11.9	58–75
Do	New York	1.3	12–26	1.9	18–37	2.7	23–46	3.5	28–53	4.3	32–58	6.0	41–68	7.8	48–76
Oak, black	Tennessee (ridge)	4.0	29	6.8	40	9.5	51	11.3	61	12.4	70	14.2	83	.....	.....
Do	Tenn. (cove and slope)	3.8	.....	6.6	.....	9.3	.....	11.5	.....	13.0	.....	14.7	.....	.....	.....
Do	Kentucky (upland and bottom).	4.4	.....	6.9	.....	9.4	.....	11.3	.....	12.6	.....	13.8	.....	14.4	.....
Do	Southern Appalachians (sprouts):														
	Ridge	4.9	38.3	6.1	47.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Slope	5.4	48.0	7.1	59.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak, black and scarlet.	Missouri (seedling)	2.6	.....	4.4	.....	6.2	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	New York (seedling)	2.2	.....	3.8	.....	5.3	.....	6.7	.....	7.7	.....	.....	.....	.....	.....
Do	New York (sprouts)	3.4	.....	4.9	.....	6.2	.....	7.2	.....	8.2	.....	.....	.....	.....	.....
Oak, chestnut	Tennessee (ridge)	0.7–0.9	29	1.6– 1.9	40	2.5– 2.9	47	3.4– 4.0	53	4.3– 5–1	58	6.1– 7.4	63	7.9– 9.8	.....
Do	Tennessee (cove)	1.7	.....	3.7	.....	5.6	.....	7.3	.....	8.9	.....	11.6	.....	13.9	.....
Do	Tennessee (slope)	1.2	.....	2.4	.....	3.4	.....	4.3	.....	5.4	.....	7.7	.....	10.0	.....
Do	Kentucky (ridge)	.7	.....	1.6	.....	2.5	.....	3.4	.....	4.3	.....	6.1	.....	7.9	.....
Do	New York (sprouts)	3.9	.....	5.3	.....	6.6	.....	7.6	.....	8.4	.....	.....	.....	.....	.....
Oak, red	North Carolina (slope)	1.5	.....	2.8	.....	4.4	.....	5.9	.....	7.5	.....	11.3	.....	15.3	.....
Do	Tenn. (cove and slope)	3.6	32	6.9	46	10.3	60	12.7	72	14.1	80	15.5	.....	.....	.....

Do	Kentucky (upland and bottom).	5.0		7.6		10.3		12.4		14.1					
Do	New York (sprouts)	4.1		6.1		8.0									
Oak, swamp white	New York (seedling)	2.7		4.4		5.9		7.1		8.3		10.2			
Do	New York (sprouts)	4.5		6.2		7.6		9.0		10.3					
Oak, white	Missouri	1.1		2.2		3.2		4.2		5.2		7.2		9.1	
Do	West Va. (second growth)	3.1		4.4		5.4		6.3		7.2		8.6		10.0	
Do	New York (seedling)	2.2		4.1		5.7		7.1		8.2					
Do	New York (sprouts)	3.9		5.4		6.6		7.6		8.4					
Do	Kentucky (upland and and bottom).	3.6		5.6		7.3		8.7		9.8		11.2		12.2	
Do	Kentucky (slope)	1.1		2.2		3.2		4.2		5.3		7.4		9.7	
Do	Tennessee (slope)	.7		1.7		2.6		3.4		4.3		6.3		8.1	
Do	Tennessee (cove)	.9		2.0		3.0		4.1		5.1		7.1		9.1	
Do	Tenn. (second growth):														
	Cove and slope	3.3	25	5.9	38	8.3	51	10.3	63	11.7	71	13.3	77		
	Ridge	3.4	22	5.7	32	8.0	43	10.0	53	11.5	63	13.4	75		
Do	Southern Appalachians (sprouts):														
	Ridge	3.9	33.2	4.4	40.8										
	Slope	4.2	31.8	5.1	37.8										
Pine, jack	Minnesota (poor, sandy soil).	3.3–3.9		4.8–5.9		6.0–7.4		7.0–8.7		7.8–9.9		9.3–11.8			
Do	Minnesota (good, sandy loam).	4.4–5.5		6.2–7.9		7.5–9.4		8.5–10.8							
Pine, loblolly	South Carolina (old field)	6.1	38	10.0	59	13.3	75	15.9	86	18.1	94	21.5	104	24.5	111
Do	South Carolina (thicket)	4.0		7.4		10.5		13.0		14.9		17.7		20.0	
Do	Arkansas (thicket)	3.1		5.0		6.9		8.8		10.7		14.1		17.2	
Do	Eastern Texas:[a]														
	Pure stand on wet prairie.	6.7		8.8											
	Pure stand on light, fairly well-drained soil.	7.6		12.8		16.9		20.0		22.3					
	Mixed with hardwoods, poorly drained soil.	2.2		3.8		5.6		7.8		9.8		13.9		17.4	
	Mixed with hardwoods, well-drained, fertile soil.	6.1		9.5		12.4		15.0		17.2					
Do	Maryland	5.0–6.8	33–55	6.4–9.1	46–69	7.7–11.0	54–78	8.8–12.7	60–87						
Pine, longleaf	Alabama	1.4	10	2.8	22	4.5	33	6.2	38	7.9	49	11.2	64	14.0	76
Do	South Carolina	1.2–2.2		3.0–3.9		4.9–5.5		6.7–7.1		8.5–8.6		11.3–12.4		13.9–15.5	
Do	Texas	1.7	24	3.3	33	5.0	50	6.6	64	8.2	71	10.8	88	13.1	93
Do	Texas (second growth)	1.5–2.8		3.1–5.8		4.9–8.4		6.8–10.4		8.6–11.6		11.5–13.7		13.9–15.2	
Pine, red or Norway	Wisconsin	2.8–5.4	35–56	5.7–10.3	58–78	8.0–13.8	70–86	9.9–16.6	77–91	11.7–18.8	82–94	14.6–21.9	88–98	16.9–24.2	91–101
Do	Wisconsin (ridge)	2.7		5.2		7.5		9.3		11.0		13.7		15.9	
Do	Wisconsin (ravine)	3.3		5.8		8.2		10.3		12.1		15.3		17.6	
Do	Minnesota	2.8–6.8	21–49	4.9–10.1	35–68	6.6–12.6	47–78	8.2–14.6	58–84	9.6–16.4	66–88	12.0–19.2	76–92	13.9–21.3	82–94
Do	Minnesota (mixture with jack pine).	1.7–2.4		3.4–4.2		4.8–5.7		6.0		6.9					

[a] Diameters inside bark on stumps 2 feet to 3.5 feet high.

TABLE 3.—*Average growth of various species in different regions*—Continued.

Species.	Region.	Age.													
		20 years.		30 years.		40 years.		50 years.		60 years.		80 years.		100 years.	
		Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.	Diameter at height of 4½ feet.	Height.
		Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Pine, scrub	Maryland	4.8–6.8	33	6.5–8.6	46	7.8–10.1	55	9.0–11.4	63	10.1–12.8	.....	.....	.....	.....	.....
Pine, shortleaf	Arkansas	5.7–7.2	45–51	8.1–9.9	54–59	10.1–12.0	60–64	11.7–13.6	64–68	12.9–15.1	66–71	15.0–17.5	71–76	16.6–19.4	74–81
Do	Missouri	1.6	.....	3.4	.....	5.1	.....	6.7	.....	8.2	.....	10.7	.....	12.7	.....
Do	N. C. (second growth)	6.3–11.6	50–69	8.4–14.5	61–73	9.9–16.5	65–75	11.0–17.6	68–76	11.7–18.4	69–77	13.0–19.4	71–78	.....	.....
Pine, white	New York	7.0–7.4	26–27	10.2–11.2	40–42	11.8–13.6	52–55	12.8–15.5	60–65	.....	.....	.....	.....	.....	.....
Do	New Hampshire	2.3–4.0	{ 14.5–24.5	3.9–6.4	{ 28.5–44	5.5–8.6	43–61	7.0–10.8	54–75	8.6–12.8	64–86	11.7–16.5	78–102	14.5–19.8	87–113
Do	Minnesota	2.8	.....	5.3	.....	7.6	.....	9.2	.....	10.7	.....	13.0	.....	14.8	.....
Do	North Carolina (slope)	2.4	.....	4.7	.....	6.9	.....	9.1	.....	11.2	.....	15.0	.....	18.0	.....
Do	Tennessee (slope)	2.2	.....	4.4	.....	6.4	.....	8.5	.....	10.7	.....	14.5	.....	17.7	.....
Do	Tennessee (cove)	1.9	.....	5.6	.....	8.5	.....	11.3	.....	13.9	.....	18.6	.....	22.1	.....
Poplar, tulip or yellow.	Tennessee	4.6–5.7	40	7.7–8.5	61	10.5–11.1	78	12.8–13.7	87	14.7–16.1	94	.....	.....	.....	.....
Do	Tennessee (cove)	3.0–3.4	.....	5.0–5.4	.....	6.9–7.3	.....	8.7–8.9	.....	10.4	.....	13.4–13.8	.....	16.3–17.0	.....
Do	North Carolina (cove)	4.6	.....	7.7	.....	10.5	.....	12.8	.....	14.7	.....	17.3	.....	19.5	.....
Do	Virginia (Quality I—seedlings).	6.5	50	9.7	64	12.6	74	15.2	83	17.3	.....	.....	.....	.....	.....
Do	Virginia (Quality II—seedlings).	4.6	36	7.4	50	10.2	64	13.0	78	15.8	.....	20.6	.....	24.6	.....
Do	Virginia (sprouts)	7.4	.....	10.2	.....	12.7	.....	15.0	.....	.....	.....	.....	.....	.....	.....
Spruce, red	Maine	.1	.....	.6	.....	.8	.....	1.1	.....	1.5	.....	2.2	.....	3.2	.....
Do	New York (spruce type)	.....	5	.4	6	.7	8	1.0	9	1.3	11	2.0	14	2.9	18
Do	New York (spruce hardwood type).	.3	5	.7	7	1.1	8	1.5	10	2.0	12	3.2	18	4.4	27
Do	New York (balsam swamp type).	.....	2	.....	4	.4	5	1.1	7	1.8	9	3.1	16	4.2	26
Do	N. H. (second growth)	2.0	13–21	4.2	24–32	5.9	35–43	6.9	43–51	7.6	49–58	8.9	56–66	.....	.....
Do	West Virginia	0.3–1.2	6–11	0.9–2.7	10–20	1.5–4.3	13–30	2.1–5.8	17–39	2.7–7.2	20–47	4.1–9.8	29–60	5.3–12.3	36–72
Tamarack	Minnesota (upland)	1.5–1.7	.....	2.5–3.4	.....	3.3–4.9	.....	4.2–6.1	.....	4.7–7.0	.....	5.9–8.5	.....	6.9–10.0	.....
Do	Minnesota (swamp)	1.6	.....	2.9	.....	4.0	.....	5.0	.....	5.8	.....	6.9	.....	7.8	.....

In this type the old trees may almost totally exclude the younger growth, or they may exist only as a few scattered individuals throughout the stand. Such material is very likely to be deteriorating in quality, and the problem is that of removing it, and at the same time providing for a new stand of seedlings. From the standpoint of strict business management timber when mature should be cut just the same as wheat or oats; and usually this is also desirable for the good of the wood lot itself. No dead or diseased timber should under any circumstances be allowed to stand. The first operation necessary then, in wood lots of this type, is the cutting out at once of the dead and diseased material. The second is to cut the mature living trees as soon as sufficient reproduction is started in the openings and marketing conditions permit a satisfactory sale. Heavy stands composed almost wholly of mature trees should not be removed all at once unless the owner expects to provide for the new crop by planting.

To secure natural reproduction the old stand will normally have to be removed in two or three cuttings, each taking from one-third to one-half of the trees. The first cutting is designed to open up the crown cover somewhat, so that the leaves on the forest floor may decompose more rapidly, the mineral soil become exposed, and the germination of seed be more certain. The remaining trees become more windfirm, and as a result of their crowns receiving more sunlight they produce more seed. When the forest floor is in good condition the second cutting can be made during the winter following a heavy seed year. With the removal of these trees the conditions will be favorable for the germination of the seed and growth of the seedlings. Neither of the first two cuttings should be so heavy that abundant light will reach the ground and encourage a heavy growth of weeds or grass. The third cutting should be made after the seedlings are well established and no longer in need of the protection of the old trees.

In wood lots where the stand of old trees is not dense and reproduction is already well started, the older trees should be cut as soon as practicable. Unless removed these will suppress and kill out young trees which would eventually be highly valuable.

2. Wood lots which are made up of a nearly even-aged stand of second growth.

In this type of wood lot, trees of undesirable species may predominate in the stand and may be crowding out the better ones; the whole stand may be overcrowded; or it may be understocked and not reproducing. The improvement of such wood lots may be brought about by various cuttings, known as "improvement cuttings," and by practices discussed under the heading "Methods of regeneration."

IMPROVEMENT CUTTINGS.

Any cutting designed to remove a portion of the trees in a stand for the benefit of the remainder is called an "improvement cutting." When made in stands of seedlings or small saplings, such cuttings are for convenience designated as "cleanings"; when made in somewhat older stands they are known as "thinnings"; when made in stands where scattered old trees are suppressing valuable young growth, they are known as "liberation cuttings."

CLEANINGS.

Often in young stands some of the less valuable species, such as ironwood, threaten to overtop, crowd out, or damage the more valuable species, such as white ash or tulip poplar; sprouts sometimes arise too thickly from the stump of trees recently cut; or the reproduction of good species is too dense. In any of these cases some of the trees should be removed. Cleanings are nothing more than the weeding out of the poorer species or the poorer individuals where these interfere with the better ones. The practice of lopping the tops of the inferior species rather than cutting them off near the ground level can be followed. These trees will then continue to live, force the growth of the better species, and still continue to shade the ground. Both to decrease costs and to avoid overcutting, only those inferior trees which are actually interfering with the better ones should be removed. The material cut out is usually too small to pay for the expense involved. The justification for cutting it lies in the bettering of the remaining stand.

THINNINGS.

In from 15 to 20 years young stands ordinarily reach a condition which makes the cutting out of some of the trees advisable. By thinning, the stand of trees that is to form the final crop can be regulated and improved. The principle is the same as that applied by truck gardeners or orchardists who thin out their crops to secure the best development of a portion rather than a poor development of the whole. By crowding at the beginning, trees of high commercial quality are produced; but if crowding is allowed to continue after the lower branches die, it will cause a stagnation both in diameter and height growth.

The presence of dead or dying trees in the stand, a very dense interlocked crown cover, stems very slender in proportion to their height, or an apparent stagnation in the height growth indicates that a thinning is needed. Unless the condition of the stand makes earlier thinnings desirable, the best practice is to defer the first one until the product is merchantable and of sufficient size to pay for the operation. Thinnings should be repeated as often thereafter as the material has accumulated in sufficient quantity again to pay for the cost. Cordwood and post material will ordinarily be obtained from the first

thinnings, and larger sized material from the later ones. In small wood lots, thinnings may be carried on by the owner at odd times at no cost other than his own labor. When poles are cut for some farm use, a little care in their selection looking to the betterment of the stand will insure a crude form of thinning.

As a rule, trees of the least prospective value should be removed. In any young stand, the trees may be assigned to several classes according to the position of their tops or crowns—dominant, codominant, intermediate, suppressed, and dead. Dominant trees are the tallest ones, whose tops receive almost complete sunlight; codominant trees are those of slightly less height with relatively narrow tops which are not fully exposed to sunlight; intermediate trees are considerably smaller than those of the first two classes, but still healthy because their tops continue to occupy open spaces in the canopy; suppressed trees are those hopelessly behind in height growth and which will either be killed by the shade of the other trees or continue to exist only as stunted individuals. The trees which remain after a thinning should, as a rule, be those which are of the best form regardless of species, the most rapid growing, and presumably of the highest final market value. The trees to be removed should, accordingly, be principally the dead ones and those of the least valuable and the most slowly growing species in the suppressed and the intermediate classes; but insect and fungous infected specimens of all classes should by all means be taken out. In order to obtain a proper opening of the crown canopy, some of the dominant and codominant trees may also have to be cut. In thinning, it must be remembered that the health and vigor of the forest trees is very much influenced by the condition of the soil. The soil should be kept fresh, soft, loose, and free of a mat of grasses. With field crops, this condition is attained by cultivation. In wood lots it must be secured by keeping the ground shaded. In making thinnings, therefore, it is desirable to retain any of the intermediate or suppressed trees which are necessary for shading the ground.

The extent to which the crown canopy of a stand may be opened depends largely upon the rate of growth of the trees and their demands for light. In general, openings should not be so large that they will not close again within from three to five years through the growth of the remaining tree tops. In stands of rapid-growing trees, such as cottonwood, tulip poplar, or red gum, the crown canopy of the dominant class of trees can be opened to a greater extent than in stands of slower-growing species, such as white oak, ash, basswood, etc. Definite rules in regard to the amount of material to be removed are not possible for all conditions, but probably not more than from one-fifth to one-fourth of the trees should be removed at a time.

The returns from thinnings will depend largely upon the market for the material removed. If the material is small and suitable only for a

poor class of cordwood, it is quite likely that the product will not pay for the cost of the operation. It must be remembered, however, that the increased growth and value of the remaining product will fully offset this cost. The material taken out in thinnings can accordingly be considered as net gain. Where the market is good, as in parts of the New England States, thinnings have been made at a net profit of from 10 cents to $2 per cord,[1] and in one 8-acre wood lot of white pine in Connecticut thinnings netted the owner $44.32 per acre.[2] When the thinning removes material suitable for posts, handle material, hub stock, small piling, or ties, the operation undoubtedly will pay for itself.

LIBERATION CUTTINGS.

Scattered old trees suppressing valuable young growth will often be found in those wood lots which have been formed by the seeding up by adjoining trees of an area such as a worn-out pasture. The first trees to start often have an abundance of room and consequently form very branchy stems and wide, spreading crowns. Such trees will never be of much value for lumber and their wide spreading habit often results in the suppression and killing of younger and better formed seedlings or saplings which ultimately would be of considerable value if the conditions were more favorable. (See fig. 1.) It is best in such cases to remove the old trees at once. A very similar condition is also found in wood lots which are the remnants of virgin stands. Scattered old virgin trees remain which, through shading, are hindering the growth of younger trees. Often these older trees, because they at one time grew in a dense stand, have a high commercial value. They should be removed as soon as a satisfactory sale can be arranged.

CUTTING OUT OF VINES.

Such vines as grape, ivy, and woodbine sometimes occur in wood lots and almost invariably twine about the trunk and throughout the tops of the trees. They affect both conifers and hardwoods and often do more damage than may be commonly realized. When of large size, their heavy foliage and small branches shade out and kill the leaves of the trees. Also by their sheer weight alone they often bend over the tops of the trees, which are thus either killed or rendered very unthrifty. (See fig. 2.) The vines themselves have no special value, and they should accordingly be eliminated by severing the parent stem near the ground. It will be best to carry on this operation while the vines are yet small and before they have done any appreciable damage; and, if lack of time prevents a thorough job, at least the larger ones which it is readily apparent are doing harm should be cut out.

---

[1] Bulletin No. 2, State Forester's Office, Mass. 1905.

[2] "Economic Thinnings of White Pine," Forestry Quarterly, Vol. V, 1907.

PASTURING OF WOOD LOTS.

Pasturing of wood lots has been one of the chief causes of their deterioration. The severity of the damage depends largely upon the number of stock and the size of the wood lot. One characteristic

FIG. 1.—Large spreading tree of poor timber form in center is interfering with thrifty young trees surrounding it and should be cut out.

of a heavily pastured wood lot is the almost complete absence of young growth, or its existence only in small ragged patches as broken or scrubby stuff. Cattle, horses, sheep, or goats eat young seedlings, particularly the hardwoods, trample them out, or brush against them and break them off. Hogs eat the seed and thus prevent reproduc-

tion from starting, or root young seedlings out of the ground, and sometimes eat the roots. (See figs. 3 and 4.)

The old growth is damaged through trampling and wounding of the roots, and through compacting the soil to such an extent that it is almost impervious to water. Horses sometimes peel the bark from

FIG. 2.—Illustrating damage done by grapevines in bending over and finally killing thrifty young trees. Vines should be cut out.

the trees. Old trees show the abuse in the dying of their tops, in a decrease in the amount of foliage, and often through the beginning of decay at the butts. A light cover of grass then makes its appearance and increases the drying out of the soil.

When the crown canopy of a wood lot is unbroken, and young growth is not desired, a few head of cattle are permissible. They

should not, however, be turned in when the ground is very soft—when the frost is going out, for instance, or during a rainy season. The

FIG. 3.—Wood lot in which cattle and hogs have run. No reproduction; roots exposed; results in little growth and a decrease in value of material.

soil is too easily compacted at that time. When it is desired to secure natural reproduction, hogs may be turned into the wood lot shortly

FIG. 4.—A well-managed second-growth wood lot in Indiana, not grazed. Maximum production of wood.

before the seed is to fall. They will root up the ground and thus put it in good condition for the reception of the seed.

Goats and sheep should be allowed in the wood lot only when it is desired to clear up brush of undesirable species, so as to make possible the reproduction of better ones. If the better species are already present in mixture with the poorer ones, some method of cutting, rather than grazing, should be followed to clear the area of the poorer species. Horses should at no time be permitted in the wood lot.

Stockmen are quite generally agreed that grass produced under the shade of timber is considerably less nutritious than the same species growing in full sunlight. It is also usually much more sparse. The actual value, then, of woodland pasture is small. One dollar per acre per year is probably a liberal estimate of the value of the forage. Thrifty fully stocked stands of timber will grow at the rate of 250 or more board feet of lumber per year. Adopting only 250 board feet as the growth and assuming the value of the standing timber to be from $5 to $8 per 1,000 feet board measure, the value of the timber growth is from $1.25 to $2 per acre per year. Stumpage values are sometimes much higher than this, especially if there is considerable white oak, tulip poplar, walnut, or other valuable species in the stand. If the timber is given good care, moreover, the growth should be as much as 500 board feet per acre per year. The larger value of the wood lot for growing timber, as compared to the value of its forage only, is apparent.

It must not be thought possible to secure this growth of timber and utilize the wood lot for pasture at the same time. Grass in the wood lot is almost an infallible indication that the wood lot is not fully stocked or is being mistreated. Grass will not thrive without strong sunlight, and in a wood lot in good condition sunlight reaches the forest floor only to a very limited extent. Pasturing and timber production can not, therefore, be practiced on the same area except to the mutual disadvantage of each; and the combination of the two will not be as remunerative to the owner as the practice of either one separately. It must be admitted, however, that the value of the shade to stock may more than offset the loss in timber growth sustained through the practice of pasturing. Just what this value is, foresters can not say; but to the farmer who pastures his wood lot and to those interested in timber production as a farm crop, studies looking to the solution of this question would be very helpful in formulating plans for the future. If shade, however, rather than forage is the wood lot's chief value to stock, it can doubtless be provided by allowing the stock to range in only a portion of the lot. The remainder can more profitably be devoted to the production of wood alone.

FIRE PROTECTION.

Because wood lots exist for the most part as small scattered bodies of timber which are constantly under the owner's supervision, there need be very little damage from fires. Owners are doubtless in some instances indifferent about fires in their wood lots because they do

not realize that these may do great damage without giving striking evidence of the fact. They burn the fallen leaves and accumulated litter of several years, thus destroying the material with which trees enrich their own soil. The soil becomes exposed, evaporation is greater, and more of the rain and melted snow runs off the surface. The roots may also be exposed and burned. Conditions are such that the vitality of the trees is weakened and their rate of growth decreased. Fires usually destroy the greater part of the young seedlings up to one inch in diameter. This young stuff is commonly called "brush," but it must be remembered that every large tree was in the "brush" stage once and that the "brush" of to-day will be the large timber trees of the future. Very severe fires destroy some of the larger trees and burn through the bark of others. These wounds lower the value of the butt log for lumbering purposes, and they afford a ready point of entrance for rot-producing fungi, which may cause deterioration in the quality of the logs for a considerable distance above the wounds. By the entrance of rot the sale value of a tree may easily be decreased by from one-half to two-thirds. Rotten logs are seldom classed as No. 1, and usually as culls. Fires, then, may be expected to destroy the vegetable manure of the forest floor, to kill young growth, to weaken vitality and growth of older trees, and to lower the sale value of timber. Through the killing by fire of the young growth, which permits more light to reach the forest floor, the growth of grass is encouraged and pasturing is probably made somewhat better, but the burning of woods to better the pasture is indefensible.

INSECTS AND FUNGI.

Damage from either insects or fungi is always possible. It is more likely to be serious with some species than with others; and fungous attacks are much more likely to be serious in woods which have been damaged by fire, grazing, lumbering, wind, or any other agency which has served to break the bark or roots and expose the living inner tissues. The damage done by a leaf-eating insect is apparent in the destruction of the foliage. When the insect is one that works under the bark and either bores into or girdles the tree, its presence is manifested by fine sawdust-like particles of wood which fall out of the burrows and collect either around the base of the tree or at the entrance of the burrows. Sap or gum also often exudes from these entrances. When the attack is serious, the leaves of hardwoods change to their autumnal color, while those of conifers become brown or red. The bark of trees killed by girdling insects becomes loose; and on its inner surface, as well as on the surface of the wood of the tree, there will be found more or less numerous regular wavy passages, or so-called galleries. These are formed by the grubs as they eat their way under the bark. The wood is their food during the course of their development.

The presence of wood-rotting fungi is indicated by hollow stems, discoloration, and rot of the wood, and by the fruiting bodies of the fungus. These are the mushroom or bracket-shaped bodies which appear somewhere on the trunk, branches, or roots of the tree, most often at some point where the tree has been wounded. Other types of fungi which may seriously damage trees but do not rot the wood may have rather inconspicuous fruiting bodies, but are manifested by an unhealthy appearance of the tree, dying of the branches, distorted twigs or branches, sunken places in the bark, and possibly other indications.

Full information in regard to the damage from either of these sources and the methods of control can usually be secured either from State experiment stations or the United States Department of Agriculture, Washington, D. C.

CARE IN LOGGING.

When the timber on the wood lot is being cut steps can be taken to insure the perpetuation of the wood lot and at the same time improve the quality of the stand. Lumbering operations which remove only trees of high quality, such as white oak or black walnut, and leave dead, dying, insect or fungous attacked specimens, and inferior trees, such as beech, should not be practiced. The beech, ironwood, dogwood, and other inferior species which remain will scatter their seed over the ground, and the future stand will be made up very largely of these. The diseased and dying trees will be a menace to the remaining healthy ones. In cutting, therefore, or in selling the standing timber, provision should be made that these inferior species be taken down to a smaller diameter than the more valuable ones and *all* defective trees be removed. To make such a provision effective, the owner should mark in some manner all the trees which he desires cut or all those which he wishes to retain in his wood lot. To induce the lumberman to take inferior species and small and defective trees, it may be necessary to make some concessions in regard to price. The trees which remain will be the nucleus of the future crop, and valuable species should be in the majority in sufficient quantities to seed up the cut-over areas.

Unless small trees bring higher prices per unit of measure than large ones, or unless they are of species which it is desirable to eliminate, they should not be cut by the wood-lot owner, nor should he allow lumbermen to cut them. Trees 10 inches and less in diameter cut only very small amounts of low-grade lumber; so that their value is very small. Ordinarily, if they are to be sawed into lumber, the lumberman figures on paying little or nothing for them. He can not afford to do otherwise. Trees of such sizes, however, are usually growing rapidly or will do so when the other trees are removed and they receive more sunlight. As they increase in size, they will cut

not only more but higher grade lumber; and they will, accordingly, increase in value in a greater ratio than in size. It is apparent that they should not be cut.

In felling trees, care should be taken not to throw them into the midst of a group of young trees, otherwise these may be seriously broken or bent. Further, by the exercise of a little care when dragging the logs out of the woods, much breakage, bending, and trampling of the young growth, or "brush," can be avoided. It must be kept in mind at all times that this "brush" is the first stage in growth of the mature timber. Every care should be taken to prevent its destruction, particularly in the better species, because it represents an established growth several years in age. A new stand of seedlings may not only be difficult to obtain, but will not have the advantage of this several years of growth. When standing timber is sold, the lumberman should be charged with protecting this young material as fully as possible.

When cutting for his own use, the owner should, so far as possible, observe rules similar to those outlined for lumbering operations. Dead and defective trees can be used for cordwood; the poorer species may sometimes serve nearly as well as the better ones for a special farm need; damage to young growth can be avoided; and the operations can be carried on at such a season of the year and in such a manner as will aid effective sprout reproduction.

METHODS OF REGENERATION.

A very striking condition in by far the greater proportion of wood lots is the absence of small trees. In those few wood lots which are fully stocked with even-aged trees of relatively even sizes, smaller trees need not be expected nor should their growth be encouraged. Where, however, as is much more commonly the case, the wood lot is made up partly of mature and partly of decadent trees which should be cut and whose crowns do not fully shade the ground, there should be young trees coming up in the openings. Under normal conditions, these young trees would be present, but because of pasturing and fires they do not start. Grass appears instead; and, if pasturing and fires continue, conditions become such that, without aid, there is little possibility of securing a natural growth of young trees.

RESTOCKING BY SEED.

If the wood lot has not been too badly abused and there is not a heavy sod of grass present, the exclusion of stock and fires will normally result in its restocking itself in time by natural seeding. Good seed years, however, occur only at intervals. Even with a good seed year, the seedlings may not be able to get a start because of the sod, the packed condition of the soil, or unfavorable weather. Natural reproduction may, therefore, be very slow, becoming satis-

factory in amount only after from 10 to 20 years. It will often be advisable, therefore, when there is a good crop of seed on the trees, to put the ground in such shape as to insure a good crop of seedlings. Before the seed is scattered from the trees in the autumn, the ground can be disk harrowed or cultivated, or hogs can be turned in to root up the soil. The seed will then lodge in the soft earth, where, upon sprouting, the roots may easily take hold. To prevent undesirable species from obtaining a foothold, any trees of such species large enough to bear seed should be cut at the time that pasturing is discontinued.

REGENERATION BY SPROUTS.

It is not always possible to secure a new growth through sprouts from the stumps of felled trees. Most conifers do not sprout effectively, and the majority of hardwoods do not sprout vigorously beyond the age of 60 years. Basswood and chestnut are exceptions, for they can be depended on to sprout well from healthy stumps up to an age of 100 years. Individual vigorous trees of other species may also often do likewise. Sprout regeneration, then, is especially applicable to hardwood stands which are to be cut when young, as, for instance, stands which are to be cut over every 20 to 30 years for posts or fuel. It should be remembered that sprouting is most vigorous from low stumps. It is also better from the stumps of trees cut during the winter or very early spring. Such sprouts, moreover, are less liable to severe winter injury at the end of their first season's growth than are those arising after timber is felled during the summer.

In felling the trees, care should be taken to injure the stumps no more than can be helped, because the best sprouts will ordinarily arise from good, clean stumps. Because of the clean cut which it makes, the axe is a better tool than the saw in felling trees where regeneration by sprouts is desired. Regardless of what tool is used, the surface of the stumps should be slanting, so that water will not collect and promote rot.

PLANTING OR ARTIFICIAL SOWING.

Some wood lots are so run down that very little seed is produced and natural reproduction can not be secured even if the area is disked or harrowed, or at least can not be secured rapidly enough to be satisfactory. Often it is desirable to grow different species than those present or to grow a greater proportion of one species than another. Sometimes no wood lot exists at all, but one is desired. In these cases artificial sowing or planting is necessary.

Where it is desired to establish a wood lot by sowing or planting, the areas to be selected for the purpose merits some attention. A large percentage of the farmers in the unwooded plains region have planted wood lots around their buildings and feed lots, primarily

for protective purposes. Although the trees were usually planted on very good agricultural soils, these men considered that tree production was justified even though the wood produced was not equal in value to the agricultural crops which could be grown on the same land. The monetary value of the protection to live stock and the saving which it has meant in winter fuel is difficult to estimate. Determinations have been made, however, in regard to the effect of trees as windbreaks upon the wind velocity and upon crops protected by them from the prevailing summer winds. It has been found in the prairie region that through the protection afforded by the most efficient grove windbreaks, the yield in farm crops is increased to the extent of the crop that could be grown on a strip three times as wide as the height of the trees.[1]

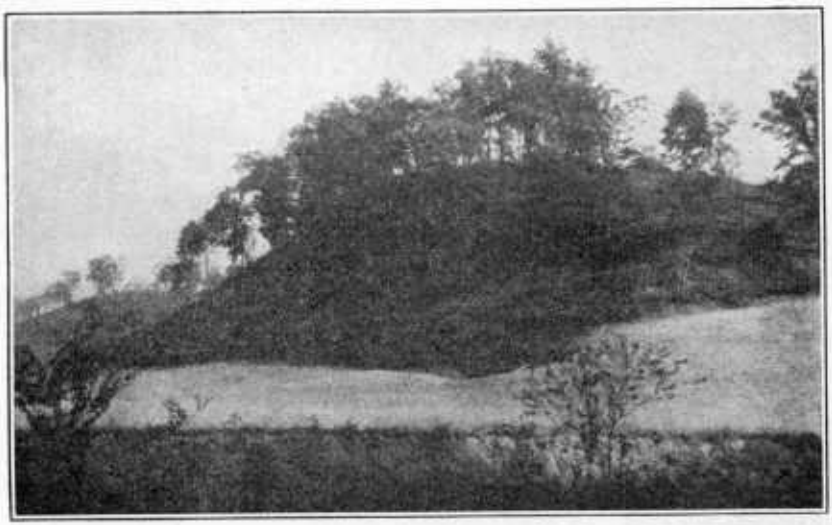

FIG. 5.—Knolls on which timber may possibly be the most profitable crop.

Where protection is not considered essential, the logical places for establishing a wood lot are on those portions of the farm which are so steep or which have a soil so rocky, sandy, or wet that the returns from agricultural crops are very meager. (See figs. 5 and 6.) Steep hillsides in particular are liable to erosion; and even though good returns can be secured for a few years from growing agricultural crops on them, they are likely eventually to become so eroded as to be practically useless for such purposes. Such lands can in the long run be more profitably devoted to the growing of timber. Low lands which are not satisfactory for the growing of farm crops will produce excellent stands of some species of timber within their natural range, such as cottonwood, red gum, elm, swamp white oak, and others of a moisture-loving kind.

[1] Forest Service Bulletin 86, "Windbreaks," 1911.

Species.—The species of trees to be given preference in planting or sowing operations should be those which are native to the region and which are of the most rapid growth. These are shown in Table 2. Though some of these most rapid growing trees are not at present so valuable commercially as the more slowly growing ones, their values are increasing and their future increase will probably be proportionately greater than that of the others.

Spacings.—The proper spacing to give in planting trees depends largely on the habit of the species and the character of the site. In general, the more tolerant the trees are of shade and the more unfavorable the site, the closer should be the spacing. Very close spacing reduces the number and the size of the branches, which means that the trees will be of higher lumber value. It means,

FIG. 6.—Type of land which should be planted to forest trees.

however, a greater death rate among them due to competition, and a higher initial cost of planting because of the greater number of trees required per given area.

On the unfavorable sites, close spacing is best. The same is true even on the better sites when cultivation can not be practiced for the first two or three years. The greater number of trees per acre offsets the higher mortality when first set out, and it results in better protection of the soil through the greater amount of shade furnished.

Species which are tolerant, or in other words will grow well under shade, such as hard maple, beech, spruce, and hickory, can be spaced more thickly than those which are not tolerant, such as cottonwood, red pine, and black walnut. The best results will ordinarily be secured by sowing or planting a mixture of species, such as the cottonwood and soft maple, the black walnut and hickory or white oak, or the

yellow poplar and hard maple. In these cases the cottonwood, black walnut, and yellow poplar would be spaced 8 to 12 feet apart and the soft maple, hickory or white oak, and hard maple would be planted midway between them. Such a combination induces rapid height growth of the first-named kinds of trees, and causes them to shed their lower branches early in life, but because of the ability of the maple, hickory, and oak to live under the shade of the cottonwood, walnut, and poplar, the ground is kept well shaded and in good condition. It being kept in mind that where wide spacings are followed, it is desirable to fill in between with more slowly growing but tolerant trees; spacings about as indicated in Table 4 should be given when the trees are to be grown to an age of 40 years or more. It is not intended to thin the stand at an earlier age.

TABLE 4.—*Spacing to be followed in forest plantation.*

Spacing in feet.					
12 by 12	8 by 8	7 by 7	6 by 6	5 by 5	4 by 5
Number of trees required per acre.					
303	680	889	1,210	1,743	2,178
Cotton-wood.	Yellow poplar. Red gum. Loblolly pine.	Short leaf pine. Chestnut. Black locust. Bald cypress.	White pine. Red pine. Red oak. Black oak. Black walnut. White ash.	Hickory. White oak. Chestnut oak. Burr oak. Post oak. Red elm. Basswood.	Hard maple. Yellow birch. Beech. White spruce. Red spruce. Fir.

The species in the last two columns will withstand considerable shade without being killed, and are the ones accordingly which can most safely be used in planting midway between such trees as are shown in the first three columns.

If seed are to be sown rather than trees planted, the quantity to be used per acre depends upon a number of considerations, such as the quality of the seed, the amount of preparation given the soil, the danger of the seed's destruction by squirrels, mice, birds, etc., its price, the rate of growth of the seedlings, and their sensitiveness to frost, drought, and other such damage. If the seed is scattered broadcast on soil prepared by plowing and harrowing like grain, some such amounts as follow will be required per acre:

White and chestnut oaks	bushels	12	Fir	pounds	45
Red and black oaks	do	8	Spruce	do	6
Ash	pounds	40	White pine	do	8
Beech	do	130	Red pine	do	5
Maple	do	40	Chestnut	bushels	8
Elm	do	24	Hickory	do	8
Birch	do	32			

If the seed are to be placed in prepared spots evenly spaced over the area, two or three such seed as walnuts, hickory nuts, or acorns should be placed in each spot and about ten of any of the other species. This is simply to guard against failure due to the seed not sprouting, its destruction by rodents, or the death of some of the seedlings after sprouting has occurred. The total quantity required per acre will be about one-fourth to one-third that necessary in broadcast sowing.

Stock.—In general there is more certainty of success from planting trees grown in a nursery than from sowing seed directly on the permanent site. The nut-bearing trees, however—walnut, oaks, and hickories—develop during their first year a deep taproot with very few laterals. This rather unfits them for growing in a nursery and later removing them to the field. The most practicable method with these species is to sow the nuts directly in cultivated spots in the field. Fall sowing is usually preferable to spring sowing unless there is danger of the nuts being disturbed by rodents.

One-year-old hardwood seedlings and two or three year old nursery-grown coniferous seedlings or transplants are the best classes of stock for planting. They are not so large as to be unduly expensive, and ordinarily small stock is more likely to succeed than large. Transplant stock of coniferous species usually has a better root and is sturdier than seedling stock. It is accordingly more suited for planting on inhospitable sites and for all sites where no cultivation can be given following planting.

Hardwood seedlings can very easily be grown for planting. The seed can be collected locally or bought. It should be sown in prepared beds in much the same manner as a vegetable crop and the young trees will require no more attention than such a crop. Coniferous seedlings or transplants require more attention for their successful production and it will usually be best to purchase such stock from a reputable nurseryman or from the State nursery, if one is maintained by the State. At present the following States maintain their own nurseries and distribute trees either free or practically at cost to planters within the State: Maine, New Hampshire, Vermont, New York, Maryland, Pennsylvania, Ohio, Michigan, North Dakota, and Kansas.

If purchased from nurserymen, the cost of hardwood stock will range from $2 to $10 per thousand trees, and that of conifers from $3 to $12. The nurseries which handle stock of certain trees and their quoted price on the same can be secured from the Forest Service, Washington, D. C., for all the more important species.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1916